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ORIGINAL PAPER

Effects of grazing on natural regeneration of tree and herb species of Kheyroud forest in northern Iran

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Abstract: We investigated the effects of grazing on natural regeneration, quantity, and diversity of woody species and dominant herb species in Kheyroud forest in northern Iran. We sampled vegetation in 5m^2 plots in custom units, which are demarcated resource areas traditionally used by local livestock producers. The authors quantified number of species, height of seedlings, and diameter of seedlings. Height classes were 0–30 cm, 30–130 cm, and >130 cm, and diameter classes were 0–2.5 cm, 2.5–5 cm and 5–7.5 cm. The density of seedlings declined with distance from corral until reaching the custom unit boundary. Most seedlings had diameters of 0–2.5 cm and heights of 0–30 cm. Predominant species, *Carpinus betulus* and *Acer capadocicum*, were in plots near the centers of custom units, *Fagus orientalis*, *Acer velutinum*, *Quercus castanifolia* species were dominant in plots near the custom unit boundary. Plant species such as *Oplismenus undulatifolius*, *Euphorbia amygdaloides*, *Rubus fruticos* and *Pteridium aquilinum* were dominant in plots nearer to forest corral. Healthy seedlings were more numerous in plots nearest the corral, while defective and deformed seedlings were more abundant away from the corral. We conclude that grazing had negative effects on the quantity and quality of vegetative regeneration. Continuation of overgrazing will not only endanger the sustainability of forest ecosystems, but also will increase the challenge of sustainable forest management.

Keywords: forest grazing; forest vegetation recovery; forest floral diversity; sustainable forestry; defective and deformed seedlings

Introduction

Survival of forests depends on sustainable exploitation and adequate regeneration (Delfan Abazry et al. 2004). Proper management can lead the forest towards the optimal purpose and regeneration plays an important role in forestry planning (Abazry et al. 2004). Many abiotic factors, such as soil moisture, light, and nutrition affect regeneration of vegetation. Human-caused factors include livestock grazing, mining, and timber harvest. These factors affect the natural regeneration of forest trees, including the establishment and stability of seedlings (Oliver et al. 1996; Barman et al. 1979). There are significant correlations between human disturbances (such as livestock grazing, anthropogenic wildfire, and logging) and regeneration, richness and abundance of trees and shrubs (Gillespie et al. 1999). Grazing of macro-herbivores has a great effect on forest plant community structure (Farris et al. 2008; Cierjacks et al. 2003). Understory perennial plants in protected areas are typically more abundant than in unprotected forest stands (Sabo et al. 2009).

Matsumoto et al. (1999) showed that severe grazing in Japan reduced sapling density and damaged tree growth. The annual migration of cattle in forest corridors in India had negative effects on forest regeneration but goat dung on the forest floor helped to increase abundance of weed species such as *Lantana camara*, *Casia tora*, *C. occidentalis*, *Opuntia dillenii*, and *Ageratum conyzoides* (Silori et al. 2001). Grazing can provide favorable conditions for dominance of woody species by eliminating herb species. But excessive grazing inhibits tree regeneration by removing seedlings and often only spiny species remain in the ecosystem (Baghere 2008). Although forest structure can be altered when saplings are browsed by wild animals such as chamois, ibex, and rabbits, damage to the forest can be caused by domestic animals such as goats, sheep and cattle, which are incompatible with management activities in the forest (Marvie et al. 2005). Because of excessive grazing, *Macchie* and *Garrrigue* formations appeared in Mediterranean forests (Atri 1997).

Cattle graze has been done from past to now in northern forest of Iran. Also grazing is executed in Kheyroud forest by local people. The regions in Kolyak and Kohnedeh are considered as summer pasture for livestock at high altitudes and Bonjehbon, Patom and Souch corral is considered as livestock pasture in low land forest in the rest of the year. Corral includes wooden installation, plastic, stone or clay or combination of them. There is a place for stopping and creates a stable for livestock to hold cattle

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in winter season.

Pasture is part of the land with comestible plant species that nourish herbivorous animals directly. Because excessive livestock grazing generally depletes forests or degrades the environment, we investigated the effect of livestock grazing on forest regeneration in the Caspian forests of Iran.

Materials and methods

Study areas

This study was carried out in Kheyroud Forest of Mazandaran Province, Iran. The study area is managed by the Natural Resources Faculty of Tehran University, and is called Educational and Research Kheyroud-kenar Forest in Patom district. This forest covers about 1,084 ha and is located 7-km east of Nowshahr between 27°36′ to 40°36′ north latitude and 32°51′ east longitude in Kheyroud region. Elevation within the study area ranges from 30 to 930 m a.s.l. (Fig. 1).

Mean annual precipitation is 1,368.3 mm and mean annual temperature is 16.2°C. October, with 237.6 mm of rainfall, is the rainiest month. Lowest rainfall of 47.5 mm occurs in July. The annual growing season is 270 d (Etemad 2002). The Emberger coefficient for this station is 179 (Korkmaz et al. 2001). Based on the De Martonne classification method, its dryness coefficient is 62.5. This region has a semi-moist climate with cold winters according to the De Martonne climagram.

Methods

We used topographic maps at 1:10,000 scales to identify custom units, which are specified areas of natural resources traditionally utilized by local people. Custom units are demarcated through certification, grazing license, or in the framework of approved natural resources projects. We confirmed custom unit locations and boundaries through field visits. We identified Bonjehbon and Patom pastures, which are sites where livestock are bedded. Pastures have improvements including shelters or stables made of wood, plastic, stone, or clay, or a combination of them. The custom unit of each pasture was determined by referral to a custom units map. Local livestocks do not travel on steep slopes so we did not sample vegetation on steep slopes. We located livestock trails by field surveys. Then we moved from each pasture to its custom unit boundary along four transects demarcated by livestock trails. Data collection was carried out on selective sampling in which results were presented in interpretive form without statistical calculations. This method is based on research by Zobeiri (2002). We established 5-m^2 sample plots of 2 m× 2.5 m dimensions. This dimension was suitable for regeneration survey because seedlings were small and their numbers were high. Sample plots were established on transects within areas of natural forest regeneration. Eighty-six sample plots were established and measurements of seedlings were: (i) height of seedling (0–30 cm, 30–130 cm, and >130 cm); (ii) the diameter collar of seedling (0–2.5 cm, 2.5–5 cm, and 5–7.5 cm). Seedling diameter is measured at the collar because it is not reached to diameter at breath height yet.

Herb coverage was estimated based on the Braun-Blanquet Method (Yospin et al. 2012). Continuous coverage was >75%, discontinuous coverage was 50%–75%, open coverage was 25%–50%, rare coverage was 6%–25%, and scattered coverage was 1%–5% and at <1%. We considered vegetation to be absent. The percentage of regeneration was calculated based on the Braun-Blanquet Method (Yospin et al. 2012) for seedlings, and dominant species were listed. Health of seedlings was assigned to one of three categories, perfect health (all buds exist and are healthy), semi-health (no terminal bud, lateral buds), browsed (missing most lateral buds and terminal bud), completely browsed, and deformed seedlings. In total, we established 26 plots in Patom custom unit, such as 8, 5, 6 and 7 plots along 1, 2, 3 and 4 routes, respectively. We established 30 plots in Souch custom unit, 9, 5, 11 and 5 plots along 1, 2, 3 and 4 routes, respectively. We established 30 plots in Bonjehbon custom unit, 14, 7, route 3 and 6 plots along 1, 2, 3 and 4 routes, respectively.

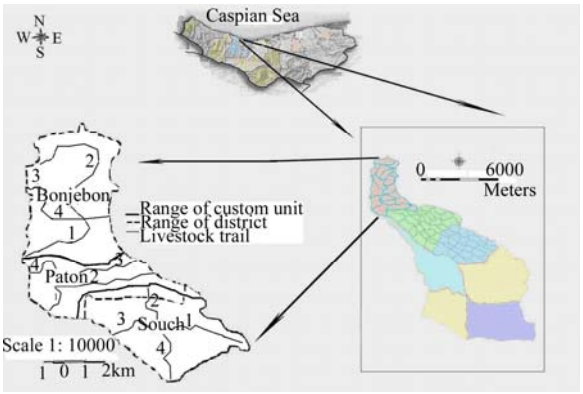

Fig. 1 Location of study area

Results

Height class

Most of the seedlings and saplings were assigned in the 0–30 cm height class. The total saplings were increased in 30–130 cm and more than 130 cm height classes in livestock trails. Number of seedlings and saplings were reduced in below 30 cm height class. Most of the seedlings and saplings were found in diameter classes of 0–2.5 cm and 2.5–5 cm. Total seedlings and saplings were more indiameter classes of 0–2.5 cm and 2.5–5 cm on plots near the center of custom unit. However, this trend was changed away from the center of custom unit and approaching the custom unit border. In other words, number of saplings was increased in 5–7.5 cm diameter class.

Species diversity

Carpinus betulus was the dominant species in plots near Patom corral. *Fagus orientalis*, *Acer cappadocicum*, *Fraxinus oriental-*

ius and *Quercus castanifolia* were dominant in the plots near the custom unit boundary. *C. betulus* was dominant in the plots near Souch corral. *F. orientalis*, *Acer velotinum,* and *A. cappadocicum* woody species were also dominant near the custom unit boundary. *C. betulus* and *A. velotinum* woody species were dominant in the plots near Bonjehbon pasture and *F. orientalis* and *A. velotinum* woody species were dominant in the plots near the border of the custom unit.

Dominant herb species

Oplismenus undulatifolius, *Euphorbia amygdaloides*, *Rubus fruticusus,* and *Pteridium aquilinum* were dominant in the plots near Patom pasture. *Hypericum androcemum* and germanous herbage species are dominant in plots near the Patom custom unit boundary. *E. amygdaloides*, *R. fruticusus* and *P. aquilinum* were dominant in the plots near Souch pasture. *H. androcemum* and germanous were dominant in plots near the Souch custom unit boundary. *E. amygdaloides*, *O. undulatifolius*, *R. fruticusus* and *P. aquilinum* were dominant in plots near Bonjehbon pasture. *H. androcemum* were dominant in the plots near the Bonjehbon custom unit boundary.

Herb coverage

Coverage of herb species declined in Patom custom units with increasing distance from the center of the custom unit to the custom unit boundary (Fig. 2). Coverage of dominant herb species declined in Souch custom units along livestock trails 1 and 4 with increasing distance from the center of the custom unit and approach to the custom unit boundary. This pattern was reversed along livestock trail 2 (Fig. 3).

The percentage of dominant herb species declined in Bonjehbon custom units with increasing distance from the center of the custom unit. This pattern was reversed along livestock trail 2 (Fig. 4).

Regeneration coverage

Regeneration coverage increased from the Patom pasture to the custom unit boundary (Fig. 5). Regeneration coverage increased from Souch pasture to the custom unit boundary (Fig. 6).

Regeneration coverage gradually increased in Bonjehbon pasture, along the livestock trail and near the custom unit boundary (Fig. 7).

Total seedlings and saplings

Total seedlings and saplings were few in Patom pasture and near its custom unit boundary (Fig. 8). The most seedlings and saplings were recorded in plots near Patom pasture at height class <30 cm and diameter classes of 0–2.5 and 2.5–5 cm.

Generally total seedlings and saplings declined in number with distance from the center of Souch custom unit to its border (Fig. 9). The declining trend of total seedlings was similar at Patom and Souch pasture. Total seedlings declined with distance from Bonjehbon pasture to its custom unit boundary (Fig. 10).

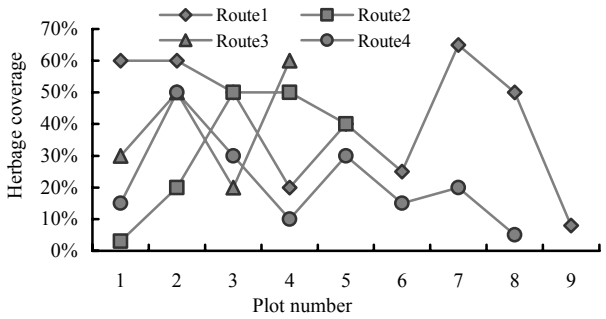

Fig. 2 Herb coverage in Patom custom unit in relation to distance from corral

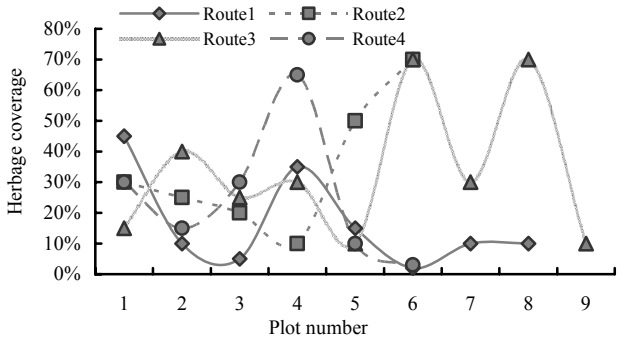

Fig. 3 Herb coverage in Souch custom unit in relation to distance from corral

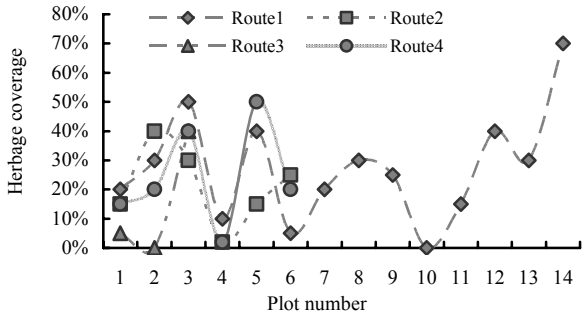

Fig. 4 Herb coverage in Bonjehbon custom unit in relation to distance from corral

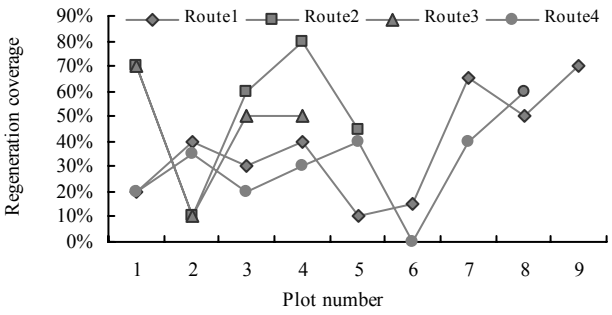

Fig. 5 Regeneration coverage in Patom custom unit in relation to distance from corral

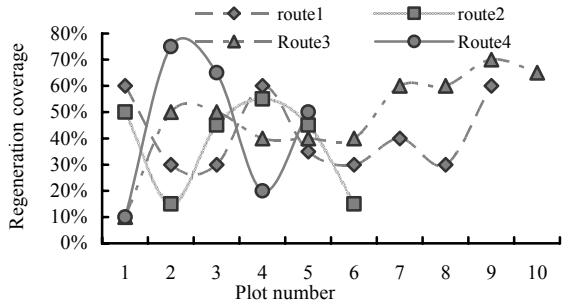

Fig. 6 Regeneration coverage in Souch custom unit in relation to distance from corral

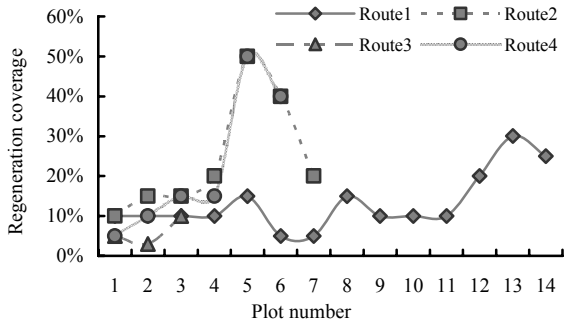

Fig. 7 Regeneration coverage in the Bonjehbon custom unit in relation to distance from corral

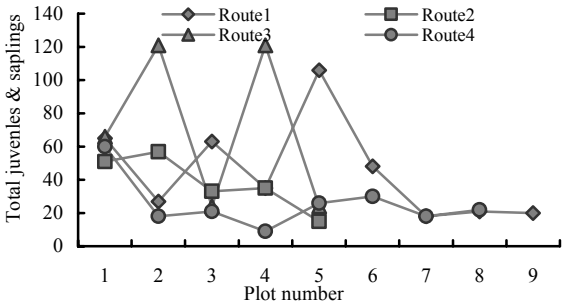

Fig. 8 Total number of seedlings and samplings in Patom custom unit in relation to distance from corral

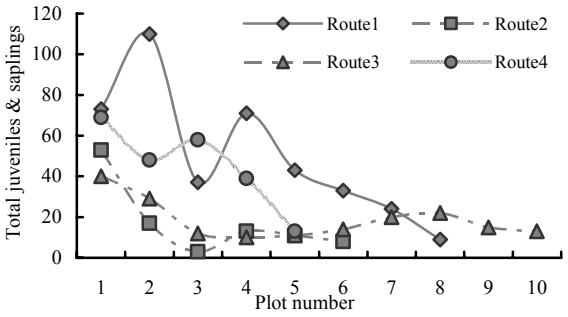

Fig. 9 Total number of seedlings and samplings in Souch custom unit in relation to distance from corral

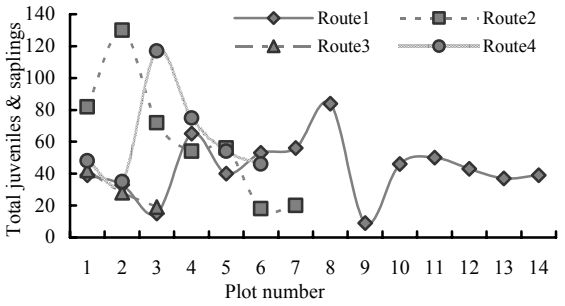

Fig. 10 Total number of seedlings and saplings in the Bonjehbon custom unit in relation to distance from corral

Health of seedlings in Patom custom units

The number of perfectly healthy and semi-healthy seedlings was greater in plots near the Patom pasture than in areas distant from the pasture. The number of browsed saplings increased in areas distant from the pasture and near the custom unit boundary. The number of perfectly healthy seedlings and saplings declined with distant from corral. The number of semi-healthy saplings increased with distance from corral. The number of saplings was greatest at the beginning of livestock trails and declined in plots near the custom unit boundary.

Health of seedlings in Souch custom units

The number of perfectly healthy seedlings and saplings declined with distance from the center of Souch custom unit. The number of semi-healthy saplings was higher in plots near the allotment boundaries. The number of browsed and perfectly browsed saplings was highest in Souch custom units distant from Souch corral and most damage was recorded near the Souch custom unit boundary.

Health of seedlings in Bonjehbon custom units

Numbers of perfectly healthy seedlings and saplings declined in plots with distance from the center of custom units (Table 1). The number of semi-healthy saplings increased in plots distant from the center of the custom unit. Total browsed saplings in Bonjehbon homestead declined in plots distant from the center of custom units. Total perfectly browsed saplings increased in plots distant from the center of Bonjehbon custom unit (Table 1).

Table 1. Percentage of regeneration seedlings in Patom, Souch and Bonjehbon custom units

Live stock	Perfectly health			Semi-health			Browsed			Completely browsed		
trails	I	II	III	I	II	III	I	II	III	I	II	III
1	83	67.5	70	8.1	14	5.8	7	13	16	7	0	4
2	40.5	51	93	9	19	1.1	31	25.2	4.5	20	4	0
3	60	41.5	74	4.3	32	6.5	34	24	13	3.3	2	0
4	67	83	79	11	4.7	1	15.5	11.4	11.7	4	0.2	73

Notes: I is Patom, II is Souch and III is Bonjehbon.

Seedling appearance

Most of the seedlings in the plots were healthy, while the frequency of deformed saplings increased with distance from the Patom corral. Numbers of deformed saplings were few. The height of healthy seedlings was usually less than 30 cm near the pasture and the number of deformed saplings >30 cm height was low near the custom unit boundary (Fig. 11).

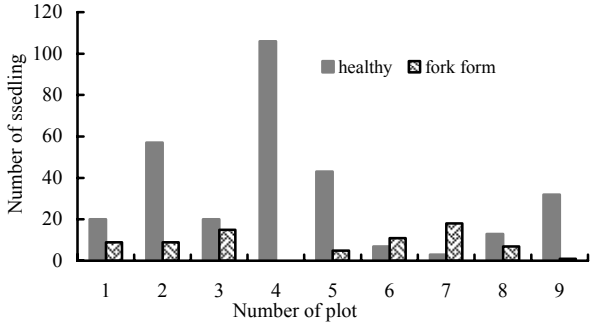

Fig. 11 Frequency of quality seedlings in route 1 Patom custom unit in relation to distance from corral

Frequency of healthy saplings was higher in plots near the Souch corral but this pattern was reversed near the custom unit boundary. Numbers of deformed seedlings increased near the custom unit boundary. Saplings <30 cm height were more numerous near the pasture. Most of the saplings, more 30 cm height exist in intervals near the custom unit boundary (Fig. 12).

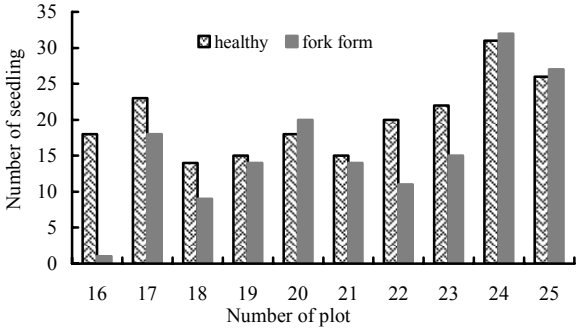

Fig. 12 Frequency of quality saplings in route 3 Souch custom unit in relation to distance from corral

The healthiest saplings were recorded in plots near the center of Bonjehbon custom unit, while more deformed and defective seedlings were recorded in plots near the custom unit boundary (Fig. 13).

Discussion

Livestock grazing is a factor that can endanger the conservation of forest. Seedlings of <30-cm height showed signs of degradation in the region. There were no domestic animals in the corral areas in summer so seedlings were not threatened by livestock grazing during summer. Livestock return from the countryside to the corral after summer. Then cattle browsed seedlings such that area around the pasture lacked healthy seedlings. This cycle is repeated every year and stops forest regeneration. Similar results were reported by (Harrington 1979; Milios et al. 2006).

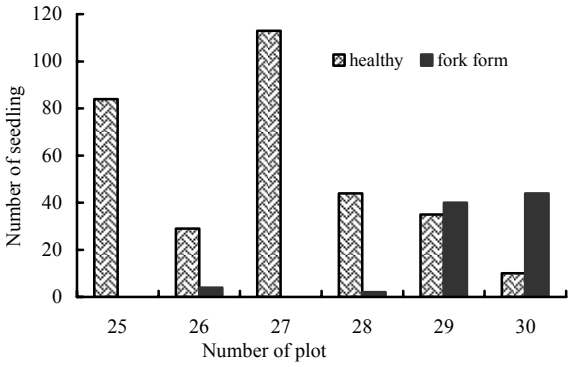

Fig. 13 Frequency of quality saplings in the route 4 Bonjehbon custom unit in relation to distance from corral

The frequency of saplings generally declined with distance from corral to the custom unit boundary. So we can confirm that excessive livestock grazing exists in plots with small seedlings near the forest pasture. Our August data indicate that forest regeneration in summer near corral was strong due to lack of livestock (cattle are in the countryside regions in this time of year). In fact, most seedlings near corral were browsed due to high grazing pressure in plots near the pasture. They are often <30 cm in height class and 0–2.5 and 2.5–5 cm in diameter class. Seedlings are usually grazed and deformed in plots near the custom unit boundary, which does not guarantee for the future of forest.

Low rates of seedling regeneration are not sustainable due to presence of livestock in the forest. Rare species were found only in habitats without grazing. Buffum et al. (2009) reported that the frequency and diversity of seedlings and saplings increased significantly over a 5-year grazing ban.

Controlled grazing is usually permitted in forests of Bhutan while livestock grazing is often prohibited in forests of Nepal. Without doubt Nepal's decision has positive ecological effects on forests which include increased forest canopy coverage, increased frequency, and natural regeneration (Buffum et al. 2008). Regeneration coverage in our study increased near corral due to the excessive grazing distant from the forest pastures.

E. amygdaloides, *R. fruticusus* and *P. auilinum* were dominant herb species at sites distant from forest pastures. The abundance of these species at these distant sites shows the impact of excessive livestock grazing near forest pastures (Belsky et al. 1999; Belsky et al. 2002). Damage to forests is caused mostly by cattle, sheep and goats. The implementation of forest recovery projects is incompatible with ranching. Separation of forest and pasture is necessary and this has been done for many years in developed countries (Mohadjer 2005).

Livestock grazing significantly damaged the health of seed-

lings in plots near custom unit boundaries. Most healthy seedlings were recorded in plots near the center of a custom unit, while defective and deformed saplings were recorded distant from the centers of custom units and nearer the custom unit boundaries. Livestock grazing pressure was relatively light on steep slopes, so saplings >30 cm height classes were recorded near the custom unit boundary and on sloping habitats.

Livestock grazing generally damages natural regeneration. Favorable regeneration is very important in forest ecosystems. This study showed that grazing has negative impacts on the quantity and quality of saplings and thus challenges forest management.

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